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DATE: May 25, 2001

TO:	Al Howard 517-373-2637 Lynn Buhl 313-392-0091 Beth Vens 734-953-1544
Dept./Location:	Michigan Department of Environmental Quality

FROM:	Jack Lanigan
Dept./Location:	Ecology Services
Fax Number:	(734) 324-6775
Phone/Ext.:	(734) 324-6219

Special Instructions:

The following letter and attachments provide the technical follow up to the Riverview feasibility study we discussed last week.

Jack

6/15/01

To: Terese VanDonsel, U.S. EPA Region 5
From: Beth Vens, MDEQ-ERD
Re: BASF - Riverview data

Thanks!

1609 Biddle Avenue, Wyandotte, MI 48192

BASF Corporation

BASF

May 25, 2001

VIA FACSIMILE AND U.S. MAIL

Mr. Alan J. Howard
Chief, Environmental Response Division
Michigan DEQ
Knapps Centre P.O. Box 30426
Lansing, Michigan 48909-7926

Ms. Lynn Y. Buhl
Director of the Southeast Offices
Michigan DEQ
300 River Place, Suite 3600
Detroit, Michigan 48207

Subject: BASF Corporation, Riverview Property
Follow up from our Meetings

Dear Mr. Howard and Ms. Buhl:

It was a pleasure to meet with you and your staff in Lansing on May 15 and 18, 2001. During those meetings, BASF Corporation promised to present clarifications on technical and administrative issues associated with our Feasibility Study Report. Those issues were identified in a letter to BASF dated May 1, 2001, from Mr. Al Howard. The issues are listed below and are followed by additional information and data. We trust these details, in addition to our Feasibility Study Report, will be acceptable as the conceptual basis for the Riverview property containment and allow BASF to move forward with construction.

A reliable impermeable vertical barrier on the property at the water's edge of the Trenton Channel.

The feasibility study prepared by URS Corporation of behalf of BASF describes a steel, sheet-pile wall as our proposed vertical barrier at the Trenton Channel. The preferred type of wall has looping, interlocking joints that are filled with grout to prevent leakage through the seams. Alternatively, a hydrating sealant placed within the joints can prevent leakage. Manufacturers of these types of walls (Waterloo Barrier™ described in the feasibility study is an example) publish test results showing the walls can reduce hydraulic conductivity to at least 10^{-8} cm/sec and can attain 10^{-10} cm/sec under ideal circumstances. BASF plans to use a steel, sheet-pile system with sealed joints that can attain these performa..ce goals. Please find an illustration of the conceptual design attached to this letter along with manufacturer's data sheets.

For comparison, bottom containment liners at engineered RCRA-regulated waste units use 10^{-7} cm/sec as the performance target (please see 264.301(c)). Therefore, the containment system proposed by BASF meets – and likely will exceed – design specifications expected to be attained at hazardous waste units.

The Elf AtoChem Company used a similar containment system and a similar conceptual design at their former East Plant, 0.75 miles north of the Riverview property and bordering the Detroit River. AtoChem used a paint-on sealant within sheet-pile joints that, when hydrated, attains a permeability less than 10^{-7} cm/sec. Several data sheets from similar applications are attached.

A drainage zone of coarse, porous material will parallel the western side of the barrier below the cap. The primary purpose for this drainage zone is to facilitate hydraulic communication between the water in the old landfill materials and the groundwater collection system.

The final specifications for the barrier, the appropriate spacing for structural tie-backs, and the composition of the drainage zone will be defined during the design phase.

Vertical hydraulic barriers along the other three sides of the Riverview property. Slurry walls proposed by BASF as vertical hydraulic barriers would need to be constructed of clean, non-native soils with a sufficiently low permeability and be keyed into the underlying clay unit.

BASF agrees to extend the vertical hydraulic barrier around the entire property. As discussed in the FS, the slurry wall will be built in perimeter areas where the composition and competency of the subsurface materials are conducive to this technology. In other areas (ie, near the Trenton Channel), BASF intends to use the steel sheet-pile described previously. BASF also will re-evaluate the unit costs for these two methods. It is possible that driving short lengths of steel sheet-pile along Jefferson Avenue (for example) may be less expensive than a slurry wall and as equally protective of the environment.

The outline of the vertical barrier will coincide with the perimeter of BASF's property as closely as practical. The entrance gate for the City's boat ramp is on our property, and we may consider jogging the wall around slightly so as not to close public access.

The slurry wall will be constructed from clean clay brought in from an off-site source (that is, non-native to the Riverview property) and mixed with bentonite and other appropriate amendments. The wall will be keyed into the underlying clay layer. The depth to the clay layer changes around the property, and BASF proposes the bottom of the slurry wall (or any other type of wall) being two to three feet below the top of the clay. Any excavated materials will be retained on the property and managed with the other fill materials.

As discussed during the meetings, the slurry wall will be designed to achieve a hydraulic conductivity of at least 10^{-7} cm/sec, and we wish to use this value to define "sufficiently low permeability". This wall will contain the waste materials on the property and be protective of public health, safety, and welfare, and the environment.

An impermeable cover over the entire area addressed by the interim response to prevent surface infiltration of storm water and snowmelt.

The feasibility study proposed constructing caps across 17 acres of the 30-acre property. The caps will be a combination of four feet of compacted clay with synthetic materials (i.e., HPDE) across most of the 17-acre area. The target permeability will be in the 10^{-7} cm/s range. Of the remaining 13 uncapped acres, four acres are leased to

/the City of Riverview (with approximately 1.5 acres being covered by asphalt), three acres are in the Trenton Channel, and four acres were planted with poplar trees. The remaining two acres are scattered around the western portion of the property and consist of the main entrance road, areas bordering the poplar groves, the proposed location of the treatment building, and small perimeter areas along the fences. These last two acres could be capped to increase the coverage to approximately 19 acres, but the discontinuous layout of these two acres may not decrease infiltration significantly.

If the cap extends across the entire property, there would be no opportunity to plant trees or other deep-rooted vegetation. Trees would be prohibited due to their roots' ability to break up the cap materials and puncture the synthetic liner.

As discussed during our meetings, we believe the 4,948 trees are capable of transpiring more water than will fall on this four-acre plot. BASF is not proposing these trees as a mechanism to clean up contamination. They are being used to reduce the amount of water we will need to manage. Additional information on the metabolism of these trees is presented below.

Finally as we discussed, the site investigation performed during 2000 found the existing clay cap to be thicker than expected (and thicker than needed). BASF proposes to re-distribute capping materials where that can be done safely. Moving the clay from place to place eventually will facilitate redevelopment of the property by lowering steep grades.

A groundwater collection system that will establish and maintain an approvable minimum measurable inward hydraulic gradient within the vertical barriers.

BASF proposed a groundwater collection system behind the steel sheet-pile wall on the down-gradient side of the property. The system employs 6-inch diameter, perforated pipe to collect groundwater and gravity-feed it to sumps. Once in the sump, the water will be pumped to an on-site treatment system.

The feasibility study did not provide details on several design concepts, so they are being presented here. BASF proposes installing the lateral collection pipes at least one foot below the mean low-water level of the Trenton Channel. Slopes to the collection sumps will be similar to those established for municipal sewers (approximately 0.5%). Float controls in the collection sumps along with a gauge in the Trenton Channel should provide adequate data on water elevations for the system to maintain groundwater elevations below the water level in the Trenton Channel.

BASF will extend the subsurface collection pipes parallel to the north and south containment walls to increase collection efficiency at the property's perimeter. The elevations for these lines will be designed after BASF acquires additional groundwater elevations and calculates a gradient. The collection pipes will extend some 200 feet back from the shoreline.

The elevation where groundwater is proposed for collection will be adequate to prevent migration off the property and protect public health, safety, and welfare and the environment. During our meeting on May 15, we discussed maintaining an inward gradient of at least one foot when measured across the containment walls. We believe this is a good target; however, some testing will be needed to assure everyone that this level is achievable.

Monitoring inside the vertical hydraulic barrier to verify inward hydraulic gradient, and monitoring outside the vertical hydraulic barriers to determine if hazardous substances are reliably contained by the barriers for as long as the contained material poses an unacceptable risk.

The feasibility study proposed 12 monitoring wells around the property to measure the success of the remedy. We can use these wells to measure groundwater elevations.

For locations along the north and south slurry walls, BASF proposes to target a one-foot difference in groundwater elevations, as measured in paired piezometers inside and outside the walls. For piezometers along the eastern sheet-pile wall, BASF proposes a one-foot difference between groundwater and surface water elevations. These differences are predicated on test results showing that this difference is achievable.

Monitoring wells outside the slurry walls may be sampled by the DEQ on a mutually agreeable schedule for agreed upon indicator parameters. Wells inside the walls are not being proposed for sampling. BASF proposes monitoring only water elevations in the Trenton Channel (outside the eastern wall) to demonstrate containment and an inward gradient.

All the administrative elements that would ordinarily be a part of a limited land use category remedial action plan (Section 20120b of NREPA).

The Consent Decree currently being negotiated with the Attorney General will specify all the necessary administrative elements. Those elements can be repeated in the feasibility study and in the remedial action plan. BASF understands multiple plans and permits will be needed including, but not limited to: a storm water management plan, contingency plans, waste management plans, operations and maintenance plan, sampling and analysis plan, Corps of Engineer's encroachment permits, etc. BASF agrees that these plans are necessary, and that they will be prepared.

Discharge of treated effluent to an on-site area is prohibited.

During our studies of potential treatment technologies, the best available control technologies have been unable to attain the GSI criterion for mercury. While the treatment methods can remove over 97% of the mercury in groundwater (as well as essentially all the other constituents), we will be unable to discharge the treated effluent to the Detroit River.

BASF considered sending the treated effluent to the Wayne County treatment works. We can meet the County's currently permitted effluent limit for mercury of 0.200 µg/L. However, this option is only a stop-gap solution available until the County receives their permit renewal. It is not environmentally appropriate for the long run. Similarly, BASF could ship the effluent to a disposal site (i.e., Michigan Recovery). This option is incorporated into the FS as an emergency disposal measure, but again, we do not consider it as environmentally appropriate when recycling is readily available. Removing the effluent containing mercury to an off-site disposal facility does not permanently reduce the toxicity or mobility of the mercury; it just moves the problem from one place to another. Therefore, BASF chose recycling the effluent as the most protective option.

BASF proposed recycling the treated groundwater through the poplar grove where low levels of mercury currently are present. On-site treatment permanently reduces the volume of mercury, and it permanently reduces the mobility by retaining the mercury within the impermeable containment walls. These are two key objective in Michigan's environmental protection act, and they are protective of public health, safety, and welfare, and the environment. The mercury remaining in the effluent eventually will move downgradient with the groundwater to be re-extracted and re-treated.

BASF and our consulting engineers currently are calculating target concentrations for mercury and the other constituents in treatment-system effluent. These targets will be presented to the DEQ for review and comment along with supporting documentation. We expect the treatment works can attain acceptable concentrations for recycling on site.

Can mercury be transpired to the atmosphere through trees, retained in leaves, and accumulate in wood? Will the leaves and the wood need to be managed as hazardous wastes?

BASF has been advised by Roux Associates on issues relating to the poplar groves. Their advice includes the amount of groundwater these trees will transpire during unit periods of time and evaluations of the trees' affinity for mercury and other chemicals.

Supporting information from Roux Associates is attached. In summary, Roux Associates found no evidence that mercury volatilizes from these trees or that mercury is taken up by the trees beyond the root zone.

Finally, in a letter to BASF dated November 3, 1999, the DEQ requested information on the anticipated, long-term performance of the poplar trees. At that time, BASF was not proposing the poplar trees as a critical piece of the remedy. Our currently proposed remedy incorporates the trees into the plan to transpire recycled groundwater; therefore, BASF asked Roux Associates to prepare responses to the questions raised in that letter. We expect to receive Roux's responses in a week or two, and we will provide their findings to the DEQ.

We trust these details, in addition to our Feasibility Study Report, will be acceptable as the conceptual basis for the Riverview property containment strategy and allow BASF to move forward with the design and construction phases.

Please call Mr. Jack Lanigan at 734-324-6219 with questions, or you may call me at 734-324-6209.

Sincerely,

Thomas F. McGourty

Thomas F. McGourty
Manager, Safety, Health, and the Environment

Attachments

cc: Beth Vens, DEQ
Keith Mast, URS
Brian Diepeveen, BASF
Ed Nuemberg, BASF (w/out attachments)
Adam Bickel, BASF (w/out attachments)
Nancy Martin, BASF (w/out attachments)
Art Nash, DEQ (w/out attachments)
Russ Harding, DEQ (w/out attachments)
Jack Lanigan

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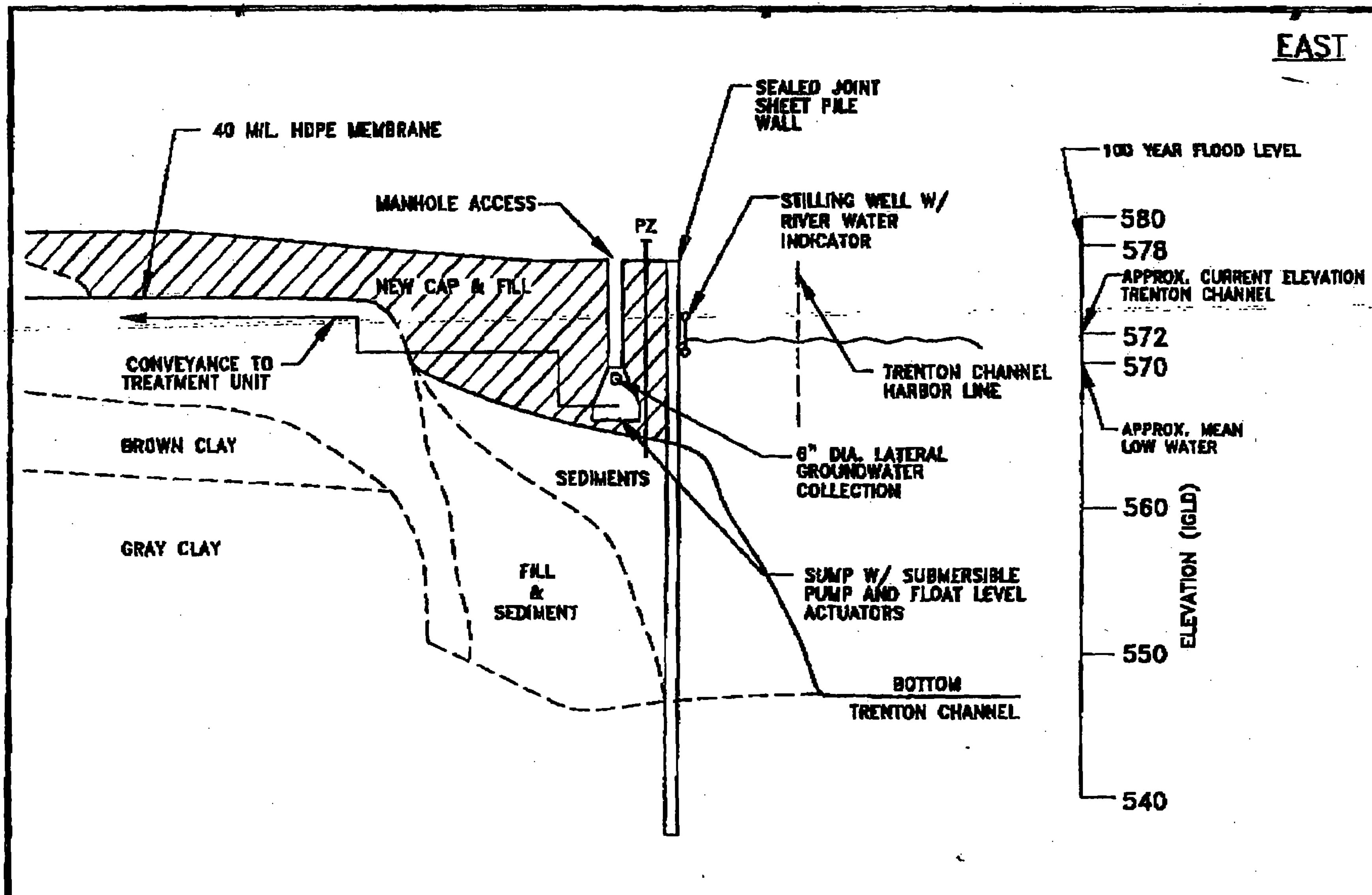
CONCEPTUAL DESIGN OF THE CONTAINMENT WALLS, THE COLLECTION SYSTEM, AND THE CAP ALONG THE TRENTON CHANNEL



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VERTICAL SCALE IN FEET

CONCEPTUAL BARRIER WALL DESIGN

BASF - RIVERVIEW, MICHIGAN

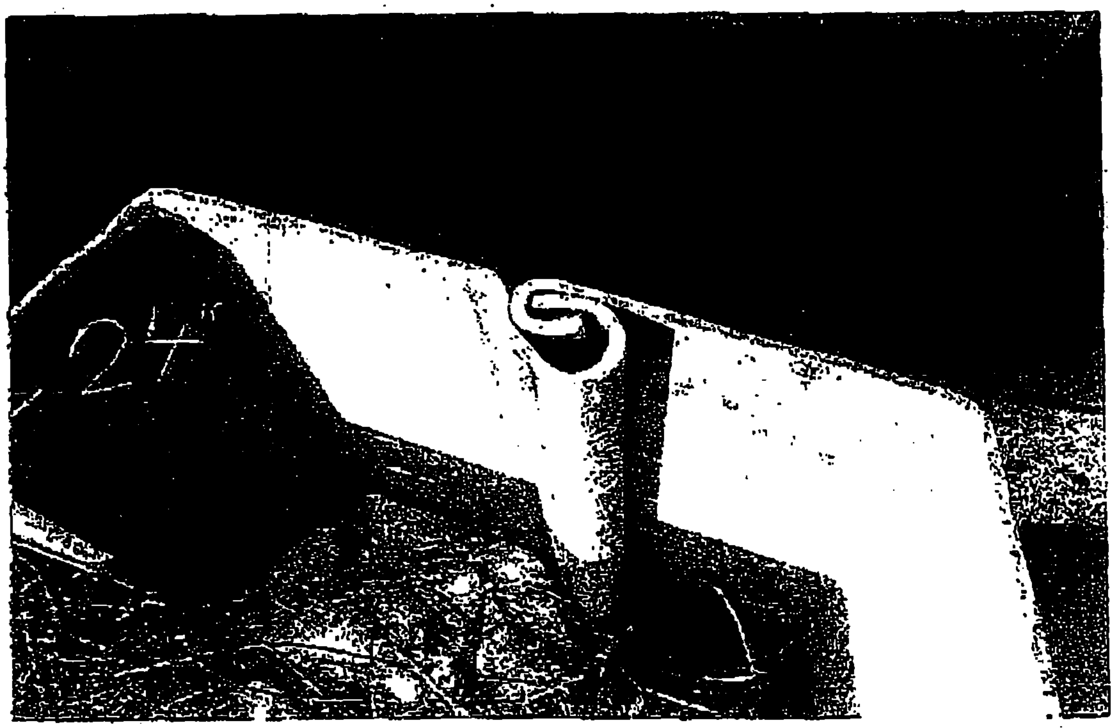
DRAWN BY: ERB	CHECKED BY: KCM	PROJECT NUMBER: BE08216	DATE: 5/24/01	FIGURE NO: 1

URS

MANUFACTURER'S DATA SHEETS ON INTERLOCKING, STEEL, SHEET-PILE WALLS

*WATERLOO BARRIER™**

A low permeability containment wall for groundwater pollution control.



Low permeability containment walls are increasingly used in groundwater pollution control and remediation. Containment enclosures can minimize or avoid the need for plume control by groundwater pumping with water treatment. Contaminants are prevented from moving off site while site control activities, such as source removal and plume remediation are carried out in the isolated subsurface environment inside the walled enclosure. The Waterloo Barrier™, constructed of steel sheet piling with sealable joints, offers significant performance and safety advantages over conventional containment walls.

*patents pending

THE WATERLOO SYSTEM

A new type of containment wall composed of sealable steel sheet piling has been developed at the University of Waterloo's Institute for Groundwater Research under the direction of Dr. John Cherry. The interlocking joints between individual sheet piles incorporate a cavity that is filled with sealant after driving to prevent leakage through the joints. The sealable cavities can be formed in two ways.

An internal cavity is formed by cold roll forming as the sheet pile itself is manufactured.

Internal Cavity

An external cavity can be produced adjacent to each joint by attaching a steel 'L' section to conventional sheet piling.

Internal and External Cavities

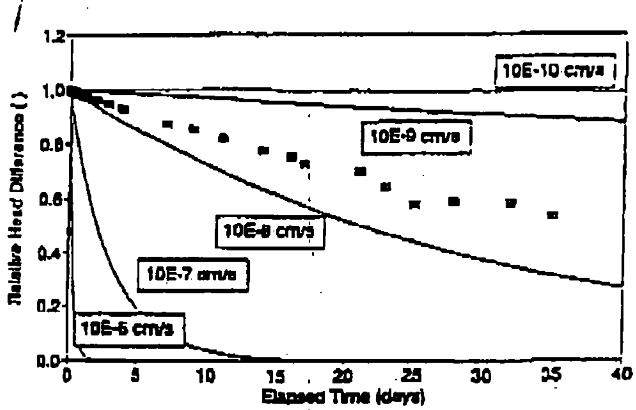
Standard pile driving equipment and techniques are used to construct a vertical sheet pile wall. Sheet piling can be driven to depths of 100 ft (30 m) or more in unconsolidated deposits lacking boulders.

A wedge or plug at the bottom of each cavity displaces soil laterally as the sheets are driven into the ground and the joints remain largely soil-free. Soil that does enter the joints is relatively loose and easily removed by jetting with water. A watertight sealant is then injected into the sealable cavities between sheet piles to create a low permeability barrier.

PERFORMANCE

The joints of conventional sheet piling are designed for mechanical strength but not watertightness. Leakage of water through the unsealed joints is acceptable for most civil engineering applications, but generally not for environmental applications. Conventional unsealed, cold roll formed sheet piling has a bulk hydraulic conductivity in the range of 10^{-4} to 10^{-5} cm/s.

In comparison, bulk hydraulic conductivities of 10^{-8} to 10^{-10} cm/s are typically achieved in test cells constructed of Waterloo Barrier™. A hydraulic conductivity at or below 10^{-7} cm/s is normally required by regulatory agencies for vertical barriers around waste sites.



Hydraulic test results of Waterloo Barrier™ test cell sealed with bentonitic grout.

DESIGN FEATURES

The internal cavity version of Waterloo Barrier™ is manufactured by cold roll forming under license by Canadian Metal Rolling Mills of Cambridge, Ontario. It is available in .295 in (7.5 mm) thickness, suitable for depths up to about 50 ft (15 m). The external cavity version can extend the depth range to 100 ft (30 m) or more using thicker, cold or hot rolled conventional sheet piling.

Sealant is selected according to site conditions and project requirements. A variety of sealant materials may be used including bentonitic grouts, vermiculitic grouts, cementiceous grouts, epoxies, and organic polymers.

QUALITY ASSURANCE AND CONTROL

Potential leak paths through the Barrier are limited to the sealed joints and therefore the joints are the focus of quality control procedures. Joints are inspected between cleaning and sealing operations to confirm that the sheets have not separated and that the complete length of the joint is open and can be sealed. Each joint is sealed from bottom to top using sealant injection lines, facilitating the emplacement of sealant into the entire length of the joint. Repair procedures can be initiated if a joint separation or blockage is suspected.

SPECIAL FEATURES

At sites where a very high degree of watertightness is desired, the Waterloo Barrier™ can be constructed with both an internal and external cavity at each joint. Two sealable cavities provide exceptional assurance that the joints are fully sealed, and also provide an opportunity for using more than one sealant at each joint to accommodate different in situ conditions inside and outside the enclosure.

For some sites a double-walled Barrier is appropriate. The narrow space between two parallel walls is used for monitoring and low flux hydraulic head control. The space between walls can also be partitioned into watertight compartments. The post-construction integrity of the containment wall can then be documented by conducting a hydraulic test of each compartment.

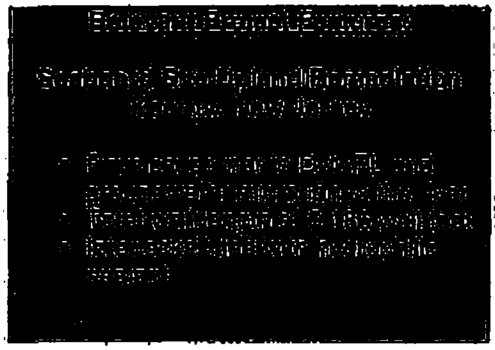
APPLICATIONS

The Waterloo Barrier™ offers considerable versatility. It can be installed to completely enclose a site to prevent off-site migration of contaminants until a remedial plan can be implemented, or to isolate a site while remedial actions are in progress.

PROJECT SUMMARY SHEETS ON INTERLOCKING, STEEL, SHEET-PILE WALL APPLICATIONS

SKYLINE Case Studies

Remediation of the Seaboard Site with ARBED AZ 18 Steel Sheet Piles



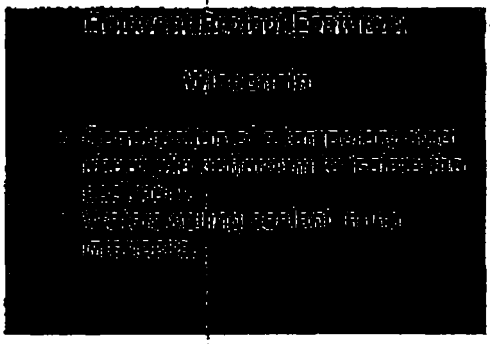
Brief Project Description:

Beazer East Inc., SK Services L.C. and Hudson County New Jersey are using the Seaboard Site in Kearny, New Jersey, for beneficial reuse of treated dredged sediment from the New York/New Jersey harbor. The remediated site is being redeveloped as a "brownfield" to add to the industrial economic base of Hudson County, New Jersey. This site is one of the largest "brownfield" sites in the eastern United States. The site is a vacant 170 acre industrial property situated along the Hackensack River in close proximity to the NY/NJ harbor. The site, developed in 1917, was used as a coal / coke processing and coal-tar processing facility. The site was built on land formed by placing miscellaneous urban fills over existing native soils. Under the Remedial Action Work Plan, approved by the New Jersey Department of Environmental Protection and Energy, the principal aspects of the remediation consist of the installation of a hydraulic containment barrier (steel sheet pile and slurry wall) adjacent to the Hackensack River and the placement of processed dredged material as structural fill, forming an engineered environmental cap over the entire site.

The objectives of installing a barrier wall system and capping the entire site are three-fold. They are to prevent potential migration of chemicals into the river, to prevent potential direct contact exposure to surface soils, and to beneficially use the land after the remediation program is successfully completed. Ultimately, this unused land will be redeveloped for new industry. In addition to the tight Larssen interlocks and wide driving widths of the ARBED AZ 13 and AZ 18 steel sheet piles, the interlocks were sealed with a hydrophilic waterstop to virtually preclude the migration of the contaminants into the Hackensack River. The contractor commenced the installation of the sheet pile wall in September 1998 and completed the project in less then three months.

SKYLINE Case Studies

Remediation Project in Wisconsin with ARBED AZ26 Steel Sheet Piles

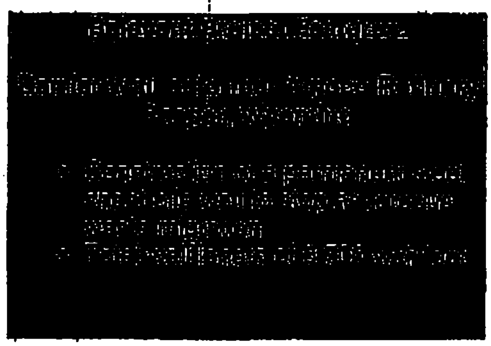


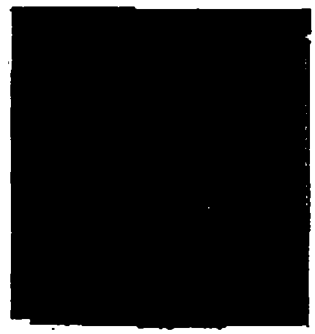
Brief Project Description:

The owner of a plant in Wisconsin was required by the EPA to contain arsenic found in the sediments near the plant, so that it would not migrate into the local river and from there into Lake Michigan. There were two major requirements for the containment of the contaminated material. Construction had to be completed between October 15th, 1998 and January 15th, 1999, and the containment system was required to be impermeable to the rock layer, approximately 50' below the ground surface. The design engineers on the project examined different methods of chemical containment and found sheet piling to be the best solution. Sheet piling's ability to create a deep impervious barrier with minimum construction time made it an ideal choice. AZ 26 with its tight Larssen interlock and wide driving width reduced the permeability of the wall significantly. The pile-driving contractor contacted Skyline Steel for sheet piles that could be delivered quick[illegible] in large quantities. Skyline proposed a water swelling product to seal the joints and pulled AZ 26 stock material from all over the country to meet delivery requirements. With two pile driving crews working from opposite directions around the cofferdam, driving of the wall was completed one month ahead of schedule, in mid December 1998. Although the river fluctuated up to 5', the level of the contained water was maintained at all times. Upon inspection, no leakage of contaminated water could be detected. So the contaminated material were contained, all parties involved considered the project a success.

SKYLINE Case Studies

Remediation of the former Casper Refinery with ARBED AZ 26 and AZ13 Steel Sheet Piles





<u>Brief Project Description:</u>

The Wyoming Department of Environmental Quality, BP Amoco Oil Company and appointed representatives of the Casper area community (Amoco Reuse Agreement Joint Powers Board) are collaborating to clean up the former Amoco refinery in Casper for purposes of redevelopment. The Non-Aqueous Phase Liquid (NAPL) Summit was held in Casper. The purpose of the Summit was to develop a scientific consensus among the experts on the panel about the best technical approach for controlling the migration of NAPL from the boundaries of the site to offsite locations along the three segments of the property. The size of the barrier wall and its composition was determined by the nature and the amount of the contamination, local geology and other factors. To stop the migration of the contaminants, the barrier walls at the site had to extend down to bedrock. Because of the nature of the contamination, steel sheet piling was thought to be the best solution. An initial purchase of AZ 13 and AZ 26 sheet piling was authorized to build a test wall. On completion of the tests, the AZ sections with their tight Larssen interlocks and wide driving widths were considered the best way to stop the migration of the contaminants.

Amoco ordered 4180 tons of AZ 26 and AZ 13 from Skyline Steel Corporation and constructed a 6,700 feet barrier along the North Platte River and Poplar Street. Sheet pile installation of Phase 1 started on May 10, 1999 and completion of pile driving of all 3 phases is scheduled for end of 1999.

SKYLINE Case Studies

Remediation of the Lipari Landfill Offsite Areas with ARBED AZ13 Steel Sheet Piles

Brief Project Description:

The 16-acre Lipari Landfill Site, in Gloucester County, New Jersey, was once ranked the No.1 Superfund NPL site in the nation. Originally the location of a sand and gravel pit, the site came to be used as an unregulated dump for municipal and industrial wastes of every type. In addition to approximately 12,000 cy of solid waste, as much a 2.9 million gallons of liquid wastes, largely uncontained, was dumped there. Extensive remediation had already occurred at the Lipari site.

Earlier remedial measures included the installation of a liner cover and slurry wall enclosing the landfill and a leachate treatment system. The persistence of odors led USEPA to conclude that further remediation would be necessary. Nearby Chestnut Branch Marsh was targeted for the next effort. Other offsite areas were also to be addressed. Chestnut Branch Marsh, considered the source of the odors, had received seepage from the base of the landfill embankment. The contractor was tasked with the removal and offsite disposal of sediments from Chestnut Branch (including the marsh), Rabbit Run, and Alcyon Lake itself. Marsh sediments were to receive thermal treatment prior to disposal. Initially, the contractor cleared the site, installed haul roads and, with steel sheet piling, constructed a lake diversion channel. Following this, a thermal treatment pad, a wellpoint interception system and an RCRA impoundment were constructed.

With preparatory work completed, i.e. clearing, grubbing, installation of ARBED AZ 13 sheet piling for a siltation pond, the contractor drained Alcyon Lake, excavated approx. 98,000 cy of sediment, and placed it, untreated, in the impoundment. The AZ sheet piles were chosen because of their large width and tight Larssen interlock, which reduced the installation time and the flow through the interlocks. Approximately 600 cy of sediment from Chestnut Branch and Rabbit Run were also placed in this impoundment, again without treatment. Sediment from the marsh was moisture-conditioned prior to placement in the impoundment. Approximately 57,500 cy of material was handled in this manner. The time of completion for the whole job was 2 years.

SUPPORTING INFORMATION ON THE METABOLISM OF CHEMICALS BY TREES

ENVIRONMENTAL CONSULTING & MANAGEMENT
ROUX ASSOCIATES INC
ROUX
209 Hunterwood Lane
Martinsburg, West Virginia 25401
TEL 304 274 0166 FAX 304 274 0528

May 25, 2001

Mr. John C. Lanigan
BASF Corporation
1609 Biddle Avenue
Wyandotte, Michigan 48192

RE: Review of Environmental Fate of Mercury in Hybrid Poplar Trees

Dear Mr. Lanigan:

Roux Associates, Inc. has completed a review of the environmental fate of mercury in hybrid poplar trees. Information used in the review was obtained from our in-house database and from an Internet literature search on the subject. Our in-house database contains over 550 peer-reviewed articles on recent phytoremediation studies. Monthly updates are performed to insure availability of the recently released literature articles. Hence, the following review should represent a state-of-the-science assessment of the environmental fate of mercury in phytoremediation applications. The literature cited in the review is provided in Attachment 1 to this correspondence.

Review of the Environmental Fate of Mercury in Plants

Mercury availability in soil is low. However, mercury plant uptake can occur through the roots or through the leaves (Mosbaek et al., 1988; Crowder, 1991; Maserti and Ferrara, 1991). Plant uptake of mercury depends on the soil conditions, uptake decreases as organic matter increases (WHO, 1989). Mercury uptake in plants tends to accumulate in the roots, translocation from the roots to the plant shoots is extremely rare, indicating that the roots serve as a barrier to mercury uptake (Patra and Sharma, 2000). Mercury concentrations in above ground portions of plants are largely dependent on foliar uptake of elemental mercury from anthropogenic emissions (Patra and Sharma, 2000; Mosbaek et al., 1988; Maserti and Ferrara, 1991). Thus, large increases in soil mercury levels produces modest increases in plant mercury concentrations by direct uptake from soil. Bench scale studies conducted on mercury contaminated soil (1.5 mg/kg) have shown significant mercury uptake (42%) in hybrid willow (Salix x) with the addition of chelating agents (Henry, 2000). However, mercury uptake was not observed in field investigations. In these bench scale studies, the mercury was found almost exclusively in the plant root zone.

Phytovolatilization has recently been proposed as remediation of soil contaminated with mercury (Rugh et al., 1996; Raskin 1996; Heaton et al., 1998; Bizily et al., 1999). This mechanism begins with the uptake of a dissolved contaminant from the soil environment. The chemical speciation of the contaminant is altered in the plant's rhizosphere (root zone) prior to uptake or after uptake. Once inside the plant, the contaminant is translocated up into the leaves where it is released to the atmosphere through transpiration (ITRC, 2001). However, only in genetically altered (i.e., transgenic) plants has mercury volatilization been successfully documented.

In recent years, it has been possible to insert genes into the DNA of plant cells and produce plants that express the product of the gene. Transgenic plants expressing mercuric reductase (i.e., plants that have been genetically modified with a gene from bacteria that reduces organic mercury to the less toxic elemental mercury) have been shown to phytovolatilize elemental mercury in contaminated solutions (Rugh et al 1996; Bizily et al 1999). Organic mercury compounds are the primary source of mercury poisoning as these compounds bioaccumulate in aquatic food chains. The genetically modified plants convert organic mercury to elemental mercury, which then volatilizes into the atmosphere. Any potential for adverse effects of elemental mercury phytovolatilized from contaminated soils is very small compared to the reduction in risk of adverse effects by hydrolyzing any methyl mercury in soils (Chaney et al., 2000).

Current regulatory concerns restrict the use of transgenic plants modified with the mercuric reductase gene. In the above laboratory trials, only the genetically modified plants were capable of phytovolatilizing mercury. In addition, the genetically modified plants were able to survive mercury concentrations that were lethal to the non-modified control plants (Bizily et al., 1999).

In summary, the results of our literature review found no evidence of mercury volatilization in non-genetically modified plants (e.g., hybrid poplars). Only in transgenetically altered plant species has this fate pathway been observed. Even in these species, phytovolatilized mercury levels are minor. According to Richard Meagher, the mercury vapor released during phytoremediation cleanup using transgenic species would be insignificant on a global scale. "The amount of vapor coming out of a site will be 10,000-fold less than the EPA emission standards." (Reuther, 1996). It is thus reasonable to conclude that mercury volatilization does not occur through the leaves of a non-transgenic species such as the hybrid poplars planted at the Riverview Site.

Please contact me if you have any questions or require additional information.

Sincerely,

ROUX ASSOCIATES, INC.

Walter H. Eifert
Principal Hydrologist

Attachment

cc: Amanda Ludlow, Roux Associates, Inc.

ATTACHMENT 1

References

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